Dieldrin Residues in Bacon Cooked by Two Methods

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The effectiveness of curing, heat processing, and cooking to reduce dieldrin residue levels in pork bellies was investigated. Cooked bacon contained 20 to 53% of the dieldrin originally present in the uncured pork samples. Most of the losses were attributed to fat rendering during cooking, although heat destruction, codistillation, and/or aeration may have occurred. Losses varied among animals as well as between cooking methods.

The potentials for removing chlorinated hydrocarbon pesticide residues from meats by preparative procedures have received limited investigation. Studying the effectiveness of cooking methods to reduce DDT residue levels in beef, Carter et al. (1948) concluded the pesticide was not materially decomposed or lost during cooking. In contrast, McCaskey et al. (1968), Liska et al. (1967), and Ritchey et al. (1967) have reported reductions in pesticide residue levels of many chlorinated hydrocarbons contained in chicken tissues. In general, the reductions were dependent on cooking time and/or temperature. In a later study, Ritchey et al. (1969) reported data suggesting leaching of fat during cooking was very effective in reducing pesticide residue levels.

It was the purpose of this study to investigate the effectiveness of curing and cooking to reduce dieldrin residue levels in bacon. The bacon, prepared from bellies taken from animals fed known quantities of dieldrin and from an animal fed no dieldrin, was cooked by pan-frying and baking. Uncured, cured, and cooked samples, as well as drip losses, were analyzed.

EXPERIMENTAL

Sample. Immediately after slaughter the belly was removed from the right side of three crossbred York-Hampshire hogs ranging in weight from 340 to 390 lb. The 10-month old, near-term pregnant hogs had been on a normal diet. During a 13-day period immediately prior to slaughter, two of the hogs received nine 1.56-g oral capsule doses of dieldrin for a total of 14.04 g, while the third hog received no dieldrin. Administration of dieldrin was randomized but no more than one dose was given in any 24-hr period. The bellies were wrapped in Saran and heavy waxed freezer paper, frozen, and stored at −20° C.

Curing and Heat Processing. After defrosting for approximately 24 hr at 4 to 5° C, portions were removed from each and and from the center of each belly. These raw portions were analyzed for dieldrin content to assess the possible effect of curing and heat processing in reducing pesticide residue levels. Bellies were cured by immersion for 3 days at 4 to 5° C in a solution containing 177.54 g of sodium chloride, 45.32 g of sucrose, 1.1332 g of sodium nitrate, and 3550 ml of distilled water. Samples were agitated daily to ensure equal curing of all areas of each piece.

For heat processing, a Hotpoint deck oven, model HJ225, equipped with a Honeywell Versatronik controller, was preheated to and maintained at 76° C ± 2° with the grids set on medium and the damper closed. Water, contained in a 17 × 11½ × 2½ in. aluminum baking pan, was present during the heat processing to minimize surface drying of the sample. The bacon was heated to an internal temperature of 50 to 54° C as indicated by a 4-in. immersion length, iron Constantan thermocouple lead inserted to the center of the sample and connected to a Brown Electronic Potentiometer High Speed Multiple Recorder. Following removal from the oven, the bacon was wrapped in aluminum foil and chilled.

Cooking. Prior to cooking by pan-frying and baking, bacon was sliced to ⅛ in. thickness using a Hobart slicer, model 410. Slices averaged 33.2, 72.9, and 49.9 g for animals 1, 2, and 3, respectively. Total, drip, and volatile losses were determined for both cooking methods as outlined by Funk et al. (1966).

For pan-frying, a Temco hot plate, model HP-2515B, set at and preheated to 218° C for 20 min, was used. Bacon slices were each cooked for 6 min in a heavy aluminum frying pan coated with Teflon II, turned, and then cooked for 5 min more.

Bacon slices were baked for 12 min on broiler-pan racks in a General Electric 30-in. compact oven preheated to and maintained at 204° C ± 1° with the grids on medium and the damper half closed. Bacon slices were drained for 3 min on each side on wire racks placed over the broiler pans used for cooking.

Extraction. For analyses, 2 to 5 g samples of uncured and cured, raw and cooked bacon, as well as drip, were used. Pans used for cooking were hexane-acetone (2:1), rinsed to ensure inclusion of all drip, and then the hexane-acetone mixture was evaporated from the drip. All samples were thoroughly blended before weighing.

Using a 200-ml extraction chamber to a Sorvall Omnimixer, samples were blended with 50 ml of hexane-acetone at speed 2½ for 4 min. The extract was then filtered through glass wool. This process was repeated three times for meat samples; however, drip samples were blended just once using the same speed for 12 min. Acetone was removed by mixing the extract with 100 to 150-ml portions of a 10% sodium chloride solution for a minimum of three times, or until any emulsions which formed during the mixing had been eliminated.

The hexane-fat-pesticide mixture was then dried with an excess of anhydrous sodium sulfate before measuring the total volume to the nearest milliliter. A 10-ml aliquot for fat analysis was removed before the sample was partitioned three times using 50-ml portions of hexane-saturated acetonitrile.

Fifty milliliters of hexane were added to the acetonitrile-pesticide mixture and the acetonitrile was removed by washing a minimum of three times, or until the elimination of any emulsions with 100 to 150-ml portions of a 10% sodium chloride solution. The sample was then dried as previously indicated and concentrated to approximately 10 ml in a 500-ml Kuderna-Danish concentrator over a steam bath.

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Table I. Percentages of Total, Drip, and Volatile Cooking Losses in Cooked Bacon

Type of Analysis	Animal	Cooking Method		Statistical Significance[a]	
		Pan-fried A	Baked B	P < 0.01	P < 0.05
Cooking losses					
Total	1	45.20 ± 1.55	48.09 ± 3.76		
	2	46.59 ± 4.45	48.76 ± 4.99		
	3	55.44 ± 4.56	52.65 ± 3.87	3 > 1, 2	
	Average	49.08 ± 5.55	49.83 ± 2.46		
Drip	1	10.52 ± 2.32	12.23 ± 5.95		
	2	16.18 ± 8.32	23.39 ± 8.14		
	3	22.60 ± 6.07	21.77 ± 2.65	2, 3 < 1	
	Average	16.43 ± 6.04	19.13 ± 6.03		
Volatile	1	34.69 ± 1.76	35.86 ± 3.42		
	2	30.41 ± 5.91	25.37 ± 4.44		
	3	32.84 ± 2.69	30.88 ± 2.64	1 > 3 > 2	
	Average	32.65 ± 2.15	30.70 ± 5.25		
Moisture	1	31.22 ± 3.43	33.57 ± 4.77		
	2	30.41 ± 5.16	32.47 ± 2.67		
	3	29.54 ± 2.92	33.75 ± 1.78		A < B
	Average	30.39 ± 0.84	33.26 ± 0.69		
Fat	1	34.34 ± 5.33	31.82 ± 4.69		
	2	38.69 ± 8.88	37.63 ± 4.57		
	3	28.60 ± 4.25	28.88 ± 1.37	3 < 2 < 1	
	Average	33.88 ± 5.06	32.78 ± 4.45		
Fat in Drip	1	76.19 ± 6.76	76.99 ± 4.63		
	2	82.68 ± 4.87	71.64 ± 10.76	A > B	
	3	72.78 ± 6.69	59.26 ± 9.78	3 < 1, 2	
	Average	77.22 ± 5.03	69.30 ± 9.09		

[a] Values underscored by the same line are not significantly different (Duncan, 1957).

Cleanup. A 500 × 20 mm Chromaflex chromatographic cleanup column fitted with a coarse porosity fritted disc was prepared by filling for approximately $^1/_2$ in. with anhydrous granular sodium sulfate followed by approximately 10 g of a Florisil-Celite mixture (5:1) and then another layer of sodium sulfate. The Florisil, which was received activated at 659° C from Floridin, Inc., was deactivated with approximately 5% distilled water.

Approximately 300 ml of hexane were used to wash the extract through the hexane-prewetted column. The extract was concentrated as previously outlined to approximately 10 ml. After measuring to the nearest 0.1 ml, the extract was transferred to a 15-ml culture tube fitted with a Teflon-lined screw cap, labeled, and stored at −20° C. Extraction and cleanup procedure, generally following those recommended by Shell (1965) except for modifications as outlined above, yielded 92% ± 1 recovery.

Dieldrin Analysis. All analyses were performed with a Varian Aerograph gas chromatograph, model 1200-1, equipped with an electron-capture detector, direct injection inlet, and a 5 ft × $^1/_8$ in. stainless steel column containing 3% SE-30 on 100/120 mesh Varaport #30. A gas flow rate of 25 ml per min prepurified nitrogen at exit port was used throughout, along with the following parameters: injection port temperature, 240° C; detector temperature, 200 to 210° C; and column temperature, 200° C.

Standards were prepared from 99+% pure recrystallized dieldrin and glass-distilled hexane. Quantitations were based on peak height.

Fat Analysis. The 10-ml aliquot was dried for $2^1/_2$ hr

at 70° C and 30 in. of mercury. The percentage of fat was then calculated using the formula:

$$\frac{\dfrac{\text{Ml extracted obtained}}{\text{10 ml aliquot size}} \times \text{Dried aliquot weight}}{\text{Original sample size (g)}}$$

Moisture Analysis. Minced samples of bacon weighing approximately 2 g were dried at 90° C and 30 in. of mercury for 6 hr. The average of duplicate determinations was calculated and expressed as the percentage moisture.

Data Analyses. Data were analyzed for variances attributable to the cooking method and animal. Duncan's multiple range test (Duncan, 1957) was used to pinpoint sources of significant differences.

RESULTS AND DISCUSSION

Bacon Curing. Curing and heat processing changed the original weight of the belly pieces very little. An average of 10.74% gain in weight was recorded after the 3 day immersion cure; however, heat processing losses averaged 11.12% during the 8.7 to 10.2 hr heating period.

Cooking Losses. Total, drip, and volatile cooking losses showed no significant differences attributable to cooking methods. Approximately 49% of the weight was lost through drip and evaporation during cooking (Table I). These losses are lower than those averaging 66% reported by Carpenter et al. (1963) for bacon sliced to 0.15 in. thickness and oven cooked at 204° C for 10 min; however, the curing procedure differed from that used in this study. Also, cooking losses,

Table II. Ppm Based on Fat Content of Dieldrin Residues in Cured Bacon

Type of Analysis	Animal	Cooking Method		Statistical Significance[a]	
		Pan-fried A	Baked B	P < 0.01	P < 0.05
Bacon	1	18.01 ± 5.02	18.05 ± 8.10		A < B
	2	14.19 ± 3.63	25.12 ± 4.56	3 < 1, 2	
	3	0.76 ± 0.62	0.42 ± 0.26		
Drip	1	20.24 ± 8.49	10.15 ± 3.30		
	2	16.59 ± 5.48	11.93 ± 6.06	3 < 1, 2	
	3	0.39 ± 0.16	0.31 ± 0.29	A > B	

[a] Values underscored by the same line are not significantly different (Duncan, 1957).

Table III. Total Micrograms of Dieldrin in Uncured, Cured, and Cooked Bacon Slices as Well as Cooking Drip

Cooking Method	Animal	Raw Meat		Cooked Meat	Drip
		Uncured	Cured		
Pan-fried	1	196.5 ± 27.5	220.4 ± 30.8	104.5 ± 30.5	52.5 ± 22.0
	2	415.2 ± 40.4	374.2 ± 36.4	166.4 ± 50.0	147.3 ± 68.4
	3	21.9 ± 1.3	8.4 ± 0.5	4.4 ± 2.5	3.1 ± 1.5
Baked	1	194.1 ± 40.5	217.7 ± 45.5	105.6 ± 72.5	33.1 ± 23.3
	2	407.2 ± 31.7	367.0 ± 28.6	64.5 ± 11.2	30.7 ± 14.4
	3	22.1 ± 2.0	8.5 ± 0.8	3.2 ± 1.4	1.6 ± 1.2

particularly drip losses, are directly related to the amount of fat present in the thin bacon slices because the fat is rendered out during cooking (Saffle and Bratzler, 1959).

Ranked in order of increasing total and drip losses were samples taken from animals 1, 2, and 3, respectively, and ranked in order of increasing volatile losses were slices taken from animals 2, 3, and 1, respectively. In addition, standard deviations indicate considerable variance in the samples from each animal (Table I).

Moisture Percentages. Uncooked cured bacon from animals 1, 2, and 3 contained averages of 44.09 ± 8.60, 42.89 ± 10.57, and 44.92 ± 3.53% moisture, respectively. These percentages were reduced during cooking and showed no significant differences due to animal (Table I).

Pan-frying, with direct contact with the heat source, reduced the moisture content (P < 0.05) more than baking. Cooking method averages for percentages of moisture are inversely related to those for volatile cooking losses (Table I).

Fat Percentages. Average percentages of 37.13 ± 8.95, 40.72 ± 2.35, and 32.81 ± 3.36 were determined as the fat content of uncooked cured bacon samples taken from animals 1, 2, and 3, respectively. As expected, lower percentages are shown for cooked samples because fat was rendered from the bacon during cooking. The fat content of cooked bacon showed no significant differences attributable to method of cooking, although the fat content did vary among animals (Table I).

Drip samples, analyzed for fat content, showed significant differences due to cooking method and animal (Table I). Apparently more moisture and/or other components extruded from the meat were evaporated during frying than during baking, since no differences due to cooking were noted in the percentage of fat in the bacon.

Dieldrin Residues. Curing solutions as well as the small amount of drip incurred during heat processing were analyzed for dieldrin content. Neither contained measurable quantities. Bacon cooked by baking had higher levels (P < 0.05) of dieldrin when calculations for parts per million were based on the fat content of the meat. As expected, bacon from animals fed known quantities of dieldrin contained higher levels (P < 0.01) of the pesticide than bacon from animals fed no dieldrin (Table II). Because animals 1 and 2 were given the same quantities of dieldrin, the data suggest differences in the metabolic and/or storage patterns of the two animals. Hayes (1965) reviewed data suggesting differences in metabolic pathways of mammal, while Nabor and Ware (1961) demonstrated differences in liver fat and kidney accumulations of lindane in chickens. It is evident from the data that the diet of animal 3 contained unknown quantities of dieldrin.

Dieldrin residue levels in the bacon were reduced by cooking, as shown by the presence of the pesticide in the drip. Drip from samples cooked by baking had, in general, lower levels (P < 0.01) of dieldrin than samples cooked by frying, thereby showing an inverse relationship with the dieldrin content of the cooked bacon. These data support the conclusions of other investigations showing that pesticide residue levels can be reduced by cooking (Ritchey et al., 1967, 1969; Liska et al., 1967; McCaskey et al., 1968).

Total micrograms of dieldrin in uncured, cured, and cooked samples, as well as drip, were calculated as shown in Table III. The standard deviations show considerable variance among samples taken from each animal and cooked by each of the two methods. The variances may be due to the position in the belly from which the sample was taken, thereby reflecting differences in the metabolism of the pesticide. As indicated previously, uncured samples were obtained from slices taken from each end and from the middle of the belly, and these results were then averaged. Slices of cured bacon for each of the cooking methods and for uncooked analyses were selected on the basis of a predetermined rotation plan designed to minimize any possible effects due to position.

The data from animals 2 and 3 indicate curing was effective in reducing the pesticide level by approximately 10 and 62%, respectively. However, data from animal 1 show approximately 12% more dieldrin in the cured bacon than was present in the uncured sample. Because of the limited number of,

animals used in this study, further investigations are indicated before conclusions can be drawn regarding the effectiveness of curing to reduce pesticide residue levels.

Pan-frying reduced the dieldrin content of samples from animals 1, 2, and 3 by approximately 53, 56, and 48%, respectively. Of the dieldrin lost, approximately 24, 39, and 37% was present in the drip of samples taken from animals 1, 2, and 3, respectively. When the bacon was cooked by baking, the dieldrin content was reduced by approximately 51, 82, and 62%, while the drip contained approximately 15, 8, and 19% of the dieldrin found in cured samples from animals 1, 2, and 3, respectively. Thus, fried bacon had approximately 53, 40, and 20% of the dieldrin originally present in the uncured pork samples from animals 1, 2, and 3, while baked samples contained approximately 54, 16, and 14%, respectively.

These data indicate fat rendering during cooking is responsible for reducing pesticide residues in foods. However, reduction by heat destruction, codistillation, and/or aeration may have occurred. Mitchell (1966) reported codistillation of dieldrin contained in water, as well as removal of dieldrin by aeration.

From the limited data available in this study, pesticide losses do occur during cooking; however, these losses appear dependent on animal as well as cooking method. No consistent pattern is shown for animal, cooking method, or curing in reducing dieldrin residue levels.

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